DESIGN OF A MODERN MATERIALS LABORATORY

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

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A THESIS

PRESENTED BY

A. TABACHNIK

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE

IN

MECHANICAL ENGINEERING

JUNE 2, 1921

APPROVED

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Professor of Mechanical Engineering

Dean of Engineering Studies

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Preface.

It is a well known fact that no theme is of value or importance unless pains have been taken to gather sufficient material, and plenty of study devoted to the subject of discussion. In undertaking this work I searched for material over the whole world and how surprised I was when I learned that only one institution in this country had a well organized laboratory and abroad only one country was able to supply me with information of value. To the countless number of inquiries made for information, the following clause claims participation to almost every reply.

> " ---- and regret that we have nothing
> here that would be of value to you -- "

But the material and knowledge I have received on the subject was sufficient to produce a design of a Materials Laboratory, herein described, which I highly recommend to the Greater Armour Institute of Technology.

A. Tabachnik.

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Introductory.

A single testing machine enclosed by three walls and a door may be considered as a Materials Laboratory and is considered as such by commercial institutions that require no more. It can readily be seen then, that a Materials Laboratory, like a Power Plant has wide limits to completeness. Likewise, each laboratory must be studied individually and designed according the various factors involved.

An institution like Armour Institute of Technology, with ambition to acquire the honor of being the best engineering school in the country, does not necessarily have to have a greater or even the likeness of the elaborate laboratory now possessed by the Massachusettes Institute which is probably rated as the best engineering school today. What it does require is good equipment that will take care of the greater demands, for either teaching or commercial purposes, and have the facilities for riging up testing apparatus to accomidate rare demands.

To give the average reader the means of valu-

ating the proposed design, this report is divided into three parts as follows:

1. A translation of the description of the Materials Laboratory of the National Academy of France, given in two sections and in detail form describing the machines and their purposes.

2. A brief outline of the layout of the Materials Laboratory of Massachusettes Institute of Technology.

3. The proposed layout in detail and foundation plans.

Part I ---- Section I.

Materials Laboratory, National Academy, France.

Main Purpose: Testing Metals.

Field of the Section. The experiments which the section is called upon to make apply to manufactured pieces or to specimens of metals with a view to determining the properties of them.

Further, its field extends to tests of bars, chains, cables, ropes, bands, fabrics, straps, timber and rubber, from the mechanical point of view, and pipes, tubes and containers from the mechanical and frictional standpoint.

The tests which it makes comprise:

Tests of tension, compression, bending, torsion, shearing, stamping, hardness, shock and a certain number of technological experiments of a general nature.

The Laboratory will be equipped to make all these tests as completely as possible; for example, in tests of tension of metals the complete experiment includes:

Determination of the limit of proportional elongation, the apparent limit of elasticity, the

elastic elongation, the modulus of elasticity. the tensile stregth, elongation, work of tension and the different remarks that would be of interest in the experiment.

The technological experiments will comprise particularly the micrographic examination of metals, tests in the working of hot metals: hammering, splitting, folding, drwing etc. A cetain number of physical studies, such as the determination of the transformation points of steels, their properties of every kind, magnetism, hardness, etc., and the determination of their qualities in the working of machine tools.

Equipment. The equipment consists of:

A large universal machine of 300 tons, permitting the test for tension and compression of pieces 25 m. (one meter = 3.28 feet) long and 1 m. square and wheel bands of about 3 m. diameter. Torsion of bars 60 mm. (about 2.5 inches) square and 1 m. long, and shearing of metals about 60 mm. thick, and punching of holes up to 60 mm. dia.

A horizontal machine, of precision, 30 tons capable of producing tension, compression and ben-

ding, in either hot or cold metals.

A vertical machine of 25 tons, Maillard machine, for tension, compression and bending hot or cols metals.

These machines are provided with different kinds of recording devices for the different kind of tests they are able to make.

A horizontal machine of 30 tons capable of working upon pieces of 3 m. long.

A machine of 4 tons, Falcot system, set up in such a way as to produce upon materials either hot or cold, tension, compression, deflection or rhytmic torsion upon elastic pieces, rubber or spring bands, with a record of the forces applied and the deformation produced. The pieces upon which it woks may be 1 m. long and 4p cm. square.

A machine of 2500 kgs. (5500 lbs.) register for testing fine wire, small bars, reistant fabrics and belts.

A Perreaux dynamometer of 500 kgs.

Four presses of 500,080, 30 and 5 tons capacity for tests on metals and wood.

An Amsler-Laffon torsion machine with recorder, allowing to twist wire 8 mm. in diameter

and 400 mm. long, either cold or hot, with registration.

A ram of 50 kgs. with stroke of 5 m. for impact of every kind.

A universal ram whose weights vary from 5 to 50 kgs. with a maximum stroke of 5 m. permitting to make impact tests by bending the material upon two points of support, bending out of perpendicular, tension or compression, either hot or cold.

The Laboratory possess a battery of muffle-hearths which permit the exposure of metals to temperatures up to 1800 degrees and to study the effects upon them of different tempering and Annealing.

In addition, two electric furnaces allowing work upon relatively small samples and accurate study of the transformation of metals. A set of photographic equipment is attached to them.

In addition, the section will be provided with standard testing weights and other accessories.

Section II.

Main Purpose: Testing Construction Materials.

Field of the Section. The experiments of this section apply to limes, cements, mortars, plasters, ceramic products, paints, bitumenated cardboard, fireproof matertials, glass etc., in a word, all construction materials other than metals.

It makes all the current tests to which one may submit raw or manufactured materials. To give an idea of the importance of these tests, let us point out that for limes and cements, the specimens can be kept for ten years in air, carbonic acid, fresh water, artificial sea water or any other product designated.

Relative to manufactured products, very interesting and important tests have already been made upon reinforced concrete floors 5 m. in length and 10 square meters in area, constructed especially for this purpose. For this test the Laboratory has at its disposal a load of about 50 tons capable of being distributed upon the floor surface. The determination of the deflection, com-

pression, and the study of the phenomena of deformation come within the province of the section which possesses the equipment necessary for these results.

The habit of this section is to present a complete plant, capable of treating the raw materials which are submitted to it for processing and the application of industrial apparatus, with the advantage, rarely found in factories, of being able to carry on scientific experiments, either in the course of manufacture or upon the finished products.

In this connection the Laboratory can cite on a case of a complete method of manufacturing hydraulic lime, lump lime and medium grade, requested by the proprietor of an important American quarry, a study for which the tested limestone had been burned, then the lime drawn out, slaked and the product obtained treated entirely industrially to give the required lime. products which wre afetrwards tested to learn its physical qualities by the methods used officially.

Equipment. The equipment of the section

divides itself into two parts:

(1) Apparatus for Preparation. The apparatus necessary for grinding, sifting, and mixing consists of :

A pounder, crusher, a bolting mill, a vertical water mixer, a large and small kneader with reversible movement, the latter capable of being heated, a small crusher, a filter press and spinning apparatus with flat and hollow plates.

For the baking of ceramic products and the creosote treatment of woods:

Two furnaces, muffled and open fire, a large vertical furnace, in all of which can all at once or simultaneously burn coal or oil, permitting a temperature of 1700 degrees, a furnace with a spiral of platinum giving 1400 degrees, an autoclave graduated to 18 kg.

(2) Testing Apparatus. The testing apparatus consists of:

A press of 500 tons for compression of samples 1 m. square and 3.5 m. high.

A universal machine of 300 tons permitting tests for compression of pieces up to 25 m. long and 1 m. sq. Bending, 6 m. long and 1 m. square.

A Hick press of 80 tons for tests of compression.

An Amsler-Laffon press of 30 tons with a reducing device to 7 tons.

A press of 5 tons with a reducing device to 2 tons.

These machines are also used by the section of metals.

An Amsler-Tetmajer machine for making of mortar specimens.

A Bohme machine and a mixer for the same purpose.

A Michaelis apparatus for tests of tension and bending.

A set of cement troughs, as well as a storeroom for keeping cement specimens.

A liquid carbonic acid machine for freezing tests.

A Dorry grinding machine for the wearing down of stones and tiles.

A machine for grinding down crushed stone.

An apparatus for testing tiles for shock.

An Amsler machine for testing permeability.

Instruments for sifting and settling.

A Martens sclerometer for testing hardness.

A Bauschinger sounding apparatus.

A Klebe wedge apparatus.

Also moulds, drying rooms, balances for determining densities, Nachet microscope and other accessories.

This bare list shows that if this section is installed as a plant, its equipment permits it to approach also purely scientific duties and studies.

The description given on the foregoing pages gives a well defined idea of the equipment of the Materials Laboratory of the Academy in France. Although a layout would be of great help to judge the completeness of the Laboratory, from the designers point of view, yet to the average reader it matters little whether the equipment occupies a space of 1000 or 10,000 feet, the description leaves a pretty well impression of its contents and their uses.

In the next section is a brief description of the Laboratory of the Massachusettes Institute of Technology, taken up from the "layout" side, giving an idea of what some designers think of the space required for completeness.

Part II.

Materials Laboratory-Massachusetts Institute.

The Laboratory is located in one section of the main building, occupying three floors and a basement, one directly overhead the other, giving practically the same arrangement for each floor. Referring to the sketch on the following page, the layout of each floor may be well noted. The approximate width of the floor space is sixty feet divided into a north and south section by a corridor seven feet wide. The north section is twenty five feet wide and approximately ninety two (92) feet long. If no consideration is given the space between the supports and wall of the south section, which is well suited for storage purposes, that section has the same floor space as the north. These two sections, together with that of the lower left hand section of the building. constitute a total floor space of about 5000 square feet and the total available floor space for the complete laboratory. deducting the foundation space required by the main machines, is approximately 18,000 square feet. a minimum estimate.

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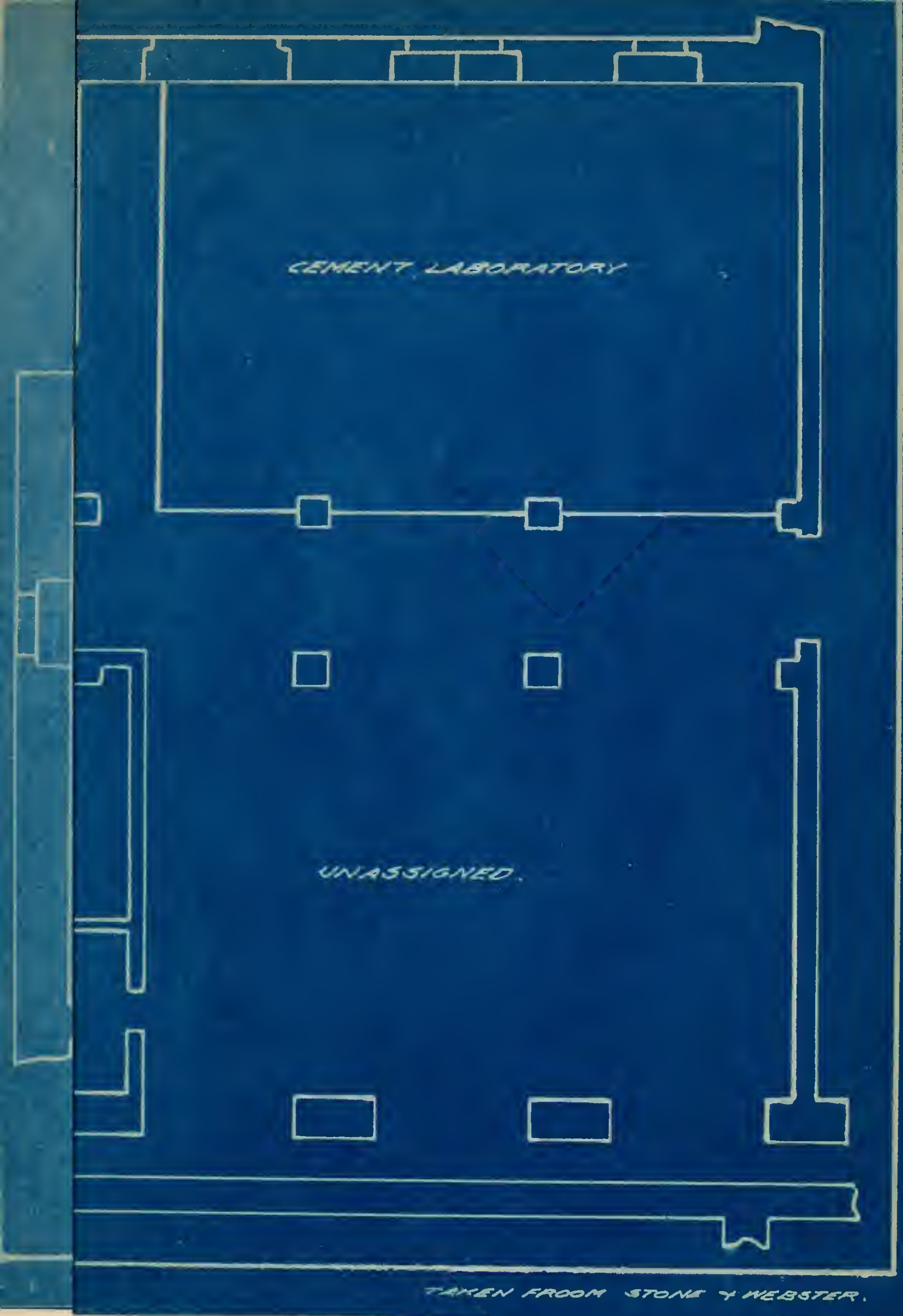
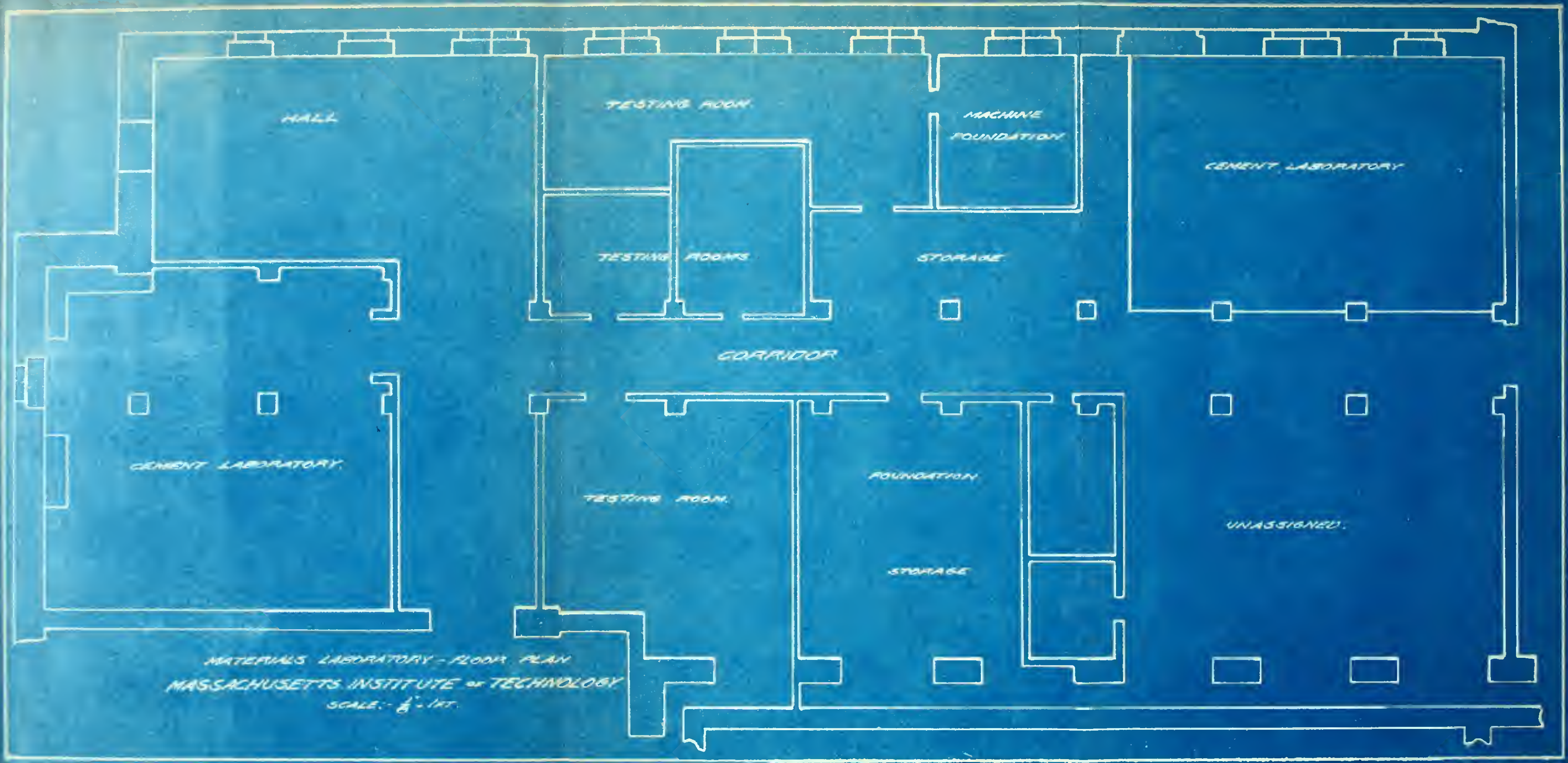


TAKEN FROOM STONE & WEBSTER.



MATERIALS LABORATORY - FLOOR PLAN
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SCALE:- 1/8" = 1 FT.

TAKEN FROOM STONE & WEBSTER.

Equipment. In taking up the equipment each floor will be given seperately.

Basement.

The essential feture of the basement is the cement laboratories, divided into two divisions, heavy and light duty. The lighter section is immediately south of the entrance hall and contains the following equipment.

Six working tables and waste cans.

A Fairbanks-Morse Scale.

One settling tank.

Three water and moist air tanks.

A Riehle cement testing machine.

One Dumping table.

One rattler.

One crusher.

One ball mill.

One Tory drill.

Two impact testers.

Beginning with the rattler and all machines that follow are concentrated over an area of 286 square feet. The total section, containing all above mentioned, has an area of 1024 square feet.

The other laboratory situated in the north east section of the building has a floor space of 1040 square feet and contains.

One concrete mixer.

One sump pump.

Two, two ton hoists.

Several storage bins.

There are few testing rooms in the basement but are of no importance.

First Floor.

The south section of the first floor contains

A rope testing machine and its attachments, the space allowed for that alone is 960 square feet.

A Riehle Testing machine,

One Press Pump.

One Amsler Press.

Emery 300,000 lbs. testing machine.

One pump.

Two-two ton cranes.

The north section contains only

100,000 lbs. beam machine.

One Olsen beam machine.

Two-two ton cranes.

Second Floor.

South End.

Offices. Print room.

50,000 lbs. hand Olsen testing machine.

20,000 lbs. Riehle.

Reserved space for future wire tension machine.

Reserved space for future wire torsion machine.

North End.

Large T. Olsen torsion machine.

60,000 in. lbs. torsion machine.

6, 000 in. lbs. torsion machine.

Space for future torsion machine.

100,000 Riehle Testing machine.

Two, 100,000 lbs. Olsen testing machines.

Storage rooms.

This is probably considered the main testing floor as the offices are here located and also the most useful machines.

Thus far no mention was made of the south west room. It is to be included in the south section or south end, whichever mentioned.

Third Floor.

South End.

Olsen oil tester.

60,000 lbs. vertical testing machine.

Cold bend testing machine.

Spring testing machine.

Repeated stress testing machine.

North end.

The north end is divided up into four divisions.

(1). Furnace Room, containing

Electric furnaces.

Pyrometers.

Tempering and case hardening tanks.

(2). Grinding Room.

An auxilary to

(3). Microscope and Specimen Room.

(4). Hardness Testing Room, containing

Brinell hardness testing machine and a few other small instruments for that purpose.

From one point of view the arrangemnt of the laboratory of the Massachusetts Institute is a very good one. In a few words it may be said that in the basement you have the Cement Laboratory, on the first floor the heavy machines, second floor the lighter stationary machines and top floor the very small machines. This arrangement is a beautiful one from the artistic point of view. From the teaching and commercial end it is not so well arranged.

It is a well know fact that the further a thing is a-way from a person the longer it will take the person to get to it, not from walking standpoint but from the standpoint of inclination of character. The tendency of a being is to remain where he is if the work in the distant room is of similar nature or of greater bore to the person and a teacher is no exception to the rule. Therefore, when an instructor has a class in the basement working on a cement experiment and he finds it necessary to return to his office on the second floor, he is bound to remain there much longer than he would if his office was in the cement laboratory, depriving the students from the possible

Knowledge and information he could have obtained during the instructor's stay.

This remark also holds good from the commercial end. When an instructor makes a test for a manufacturing concern and returns to his office to compute the results and finds that there is some misleading part in the data taken, some small error, say reading the elongation of a malleable test bar 5/8 of an inch instead of 5/16 of an inch after breaking, he will return to make sure of his reading if the testing room is right next to the office, but will either consider it a bar with an exceptional elongation or say to himself that he was mistaken and call it 5/16 or 3/8 of an inch if the office is far away.

These remarks may be considered minor matters but are influencial.

Part III.

Proposed Design.

Since the kind or size of building has not been decided on by the authorities of the institute, an exact layout of the test rooms is not possible. However, the proposed floor layout, drawing 2, is designed in such a way as to be able to place the rooms in any position to suit the average school building.

The laboratory is divided up into three main rooms, the main testing room, 50x50 feet, the small instrument room, 25x50 feet and the cement laboratory, 25x50 feet. The main testing room is divided into two section and may be made into two seperate rooms if it is so necessary. Each section is 25x50 feet. The result of such a division is four plots of equal area totaling 5000 square feet for the complete Materials Laboratory.

This laboratory, with the equipment recommended should be capable of making any physical

test that may be requested of it to make.

Taking up the floor layout first the main testing room has all the heavy duty work on one end, the torsion and lighter testing on the other end. The central room contains all the heat treating machines, hardness, durability and other testing machines. This room supplies the office space for the teaching staff and next to the office are a number of tables for students use. The cement laboratory is arranged in three parts, the heavy duty end in the back, in front the working end and a small front room for the testing machines.

Each of these room and the equipment will be taken up in detail.

Main Testing Room.

Referring to drawing No. 20 it will be noticed that the upper section is the heavy tension and compression end, the lower left section the torsion end and to the right the light stationary working machines.

Equipment.

A 400000 Olsen Universal Structural Testing Machine.

This machine is adapted for eight feet in compression and six feet in tension, allowing for elongation. Four guide columns, one in each corner, are provided to resist the side thrust on the crosshead. Extensions for beams may be provided up to 20 feet and if such provision is made the extensions should be arranged so as to be below the floor level. See drawing No. 6

A 100,000 Olsen Testing Machine.

This is a three screw type machine with Automatic and Autographic attachments, adapted for specimens eight inches long and one inch diameter the upper limit. It is also provided

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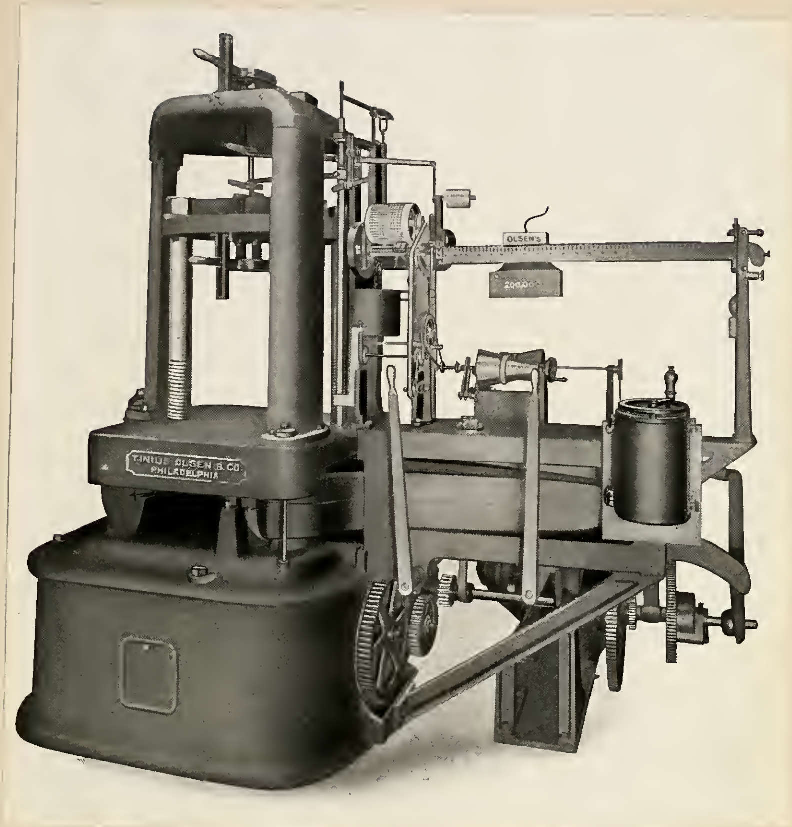


100,000 lbs. Olsen Universal Testing Machine.

with special weights to reduce to capacity to 50,000 and 10,000 lbs. See drawing No. 4.

A 200,000 lbs Riehle Testing Machine.

This machine is adapted for tension and especially for compression including heavy cement specimens. See drawing No.5

A 230,000 in. lbs. Olsen Torsion Testing Machine.

This machine is capable of handling specimens up to seven feet in length and has the Automatic and Autographic instruments attached.

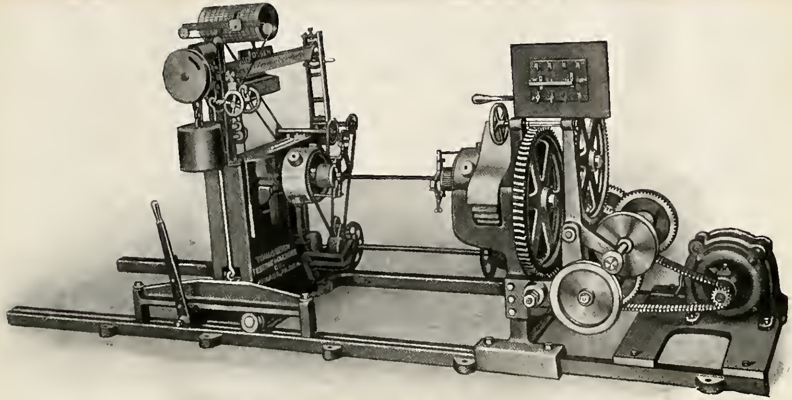
A 50,000 in. lbs. Olsen Torsion Machine for very small work.

A 500 in. lbs. Wire Torsion Testing Machine.

This machine is adapted for any size wire and when very light wire is to be tested the weighing system on the machine may be changed to reduce the capacity as low as 50 in. lbs.

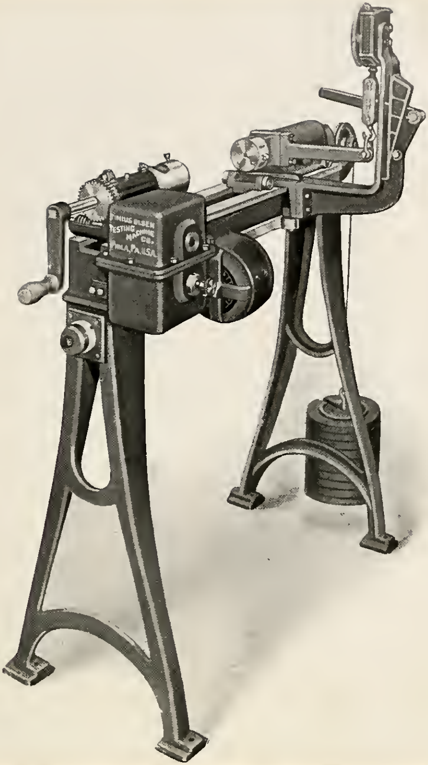
A 10,000 Olsen Wire Tension Machine

A 60,000 Olsen Testing Machine, four



Olsen Torsion Testing Machine.

230,000 in. lbs.



Olsen Wire Torsion Testing Machine.

screw type adapted for very small work.

A 50,000 lbs. Belt Testing Machine.

Also tables, cupboards and display boards.

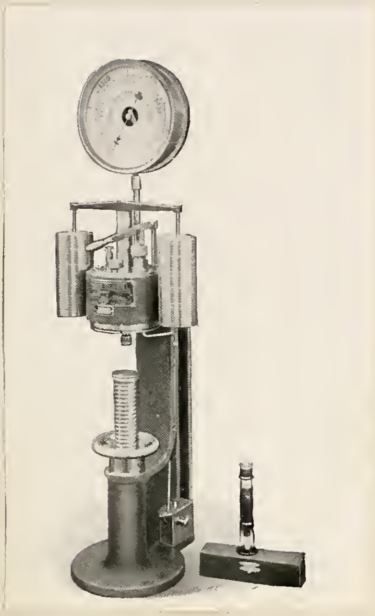
The room should also be equipped with two-two ton hoists or cranes for moving heavy work when necessary.

Central Testing Room.

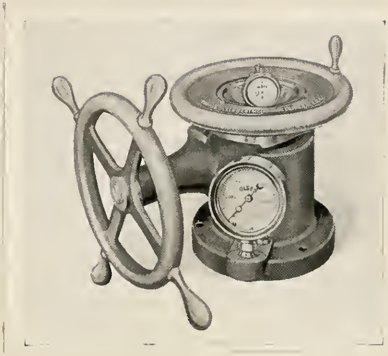
Referring to drawing No.2A the general layout of the room is noticed.

At the upper left is the lathe and drill press for preparing quick samples. Upper center the tempering section and toward the right the electric furnaces and pyrometers.

Below that is a table for small testing apparatus such as a Brinell testing machine, ductility testing machine, ball bearing machine etc. In the center of the room is unassigned space for additional instruments that may be required, such as microscopic instruments etc.



Brinell Harness Testing Machine.



Olsen Ductility Testing Machine.

At the lower left is the office with exits to the main testing room. It contains a desk in the upper center. To the right immediate use files and to the left room for interviewers. The lower end is occupied by experimental files and a small library on testing materials.

Towards the right end of the room are two study tables for the students to prepare their data sheets etc.

Cement Laboratory.

Equipment.

Storage Bins.

These bins are for the use of raw materials such as sands, cements and rocks.

A Cement Mixer of medium capacity.

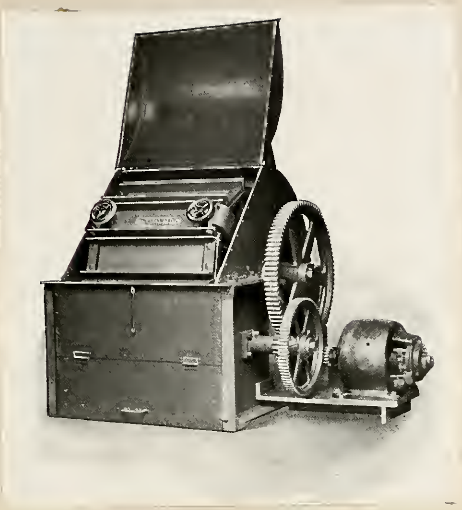
One Crusher.

One Rattler.

One Ball Mill

One 200 lbs. Fairbanks Scales.

With the above machines, any cements or rocks may be given the desired preparation for test.



Olsen Encased Rattler.

Below these machines are the working tables for preparing the various desired briquettes and on each side are the cupboards for storing the various moulds and tools. Towards the south end are settling tanks, water and moist air tanks for the prepared samples to be stored for any required period, as the test may require.

The test room is independent of the work room and contains.

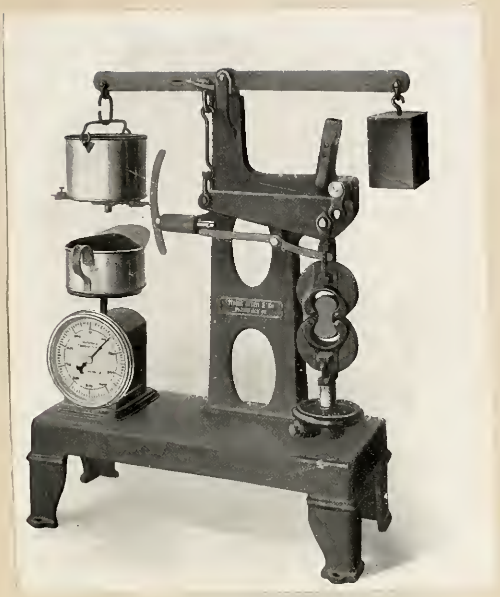
One Shot Cement Testing Machine.

A 40,000 Hydraulic Compression testing Machine, with an adjustable top head and two speeds.

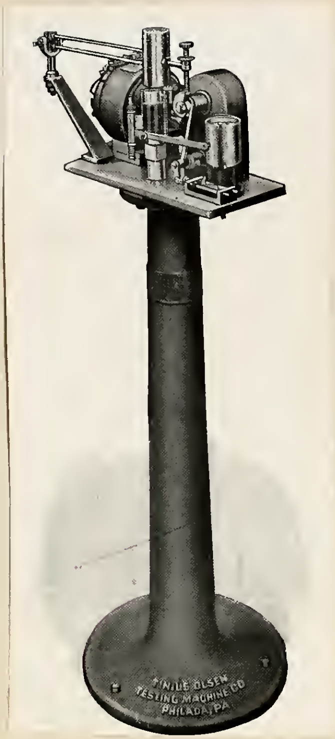
A Dorry Hardness Tester and

One Impact Testing Machine for Cements.

In the test room a cupboard is placed for storing away any tested specimens that one may desire and files for data sheets and records.



Shot Cement Testing Machine.

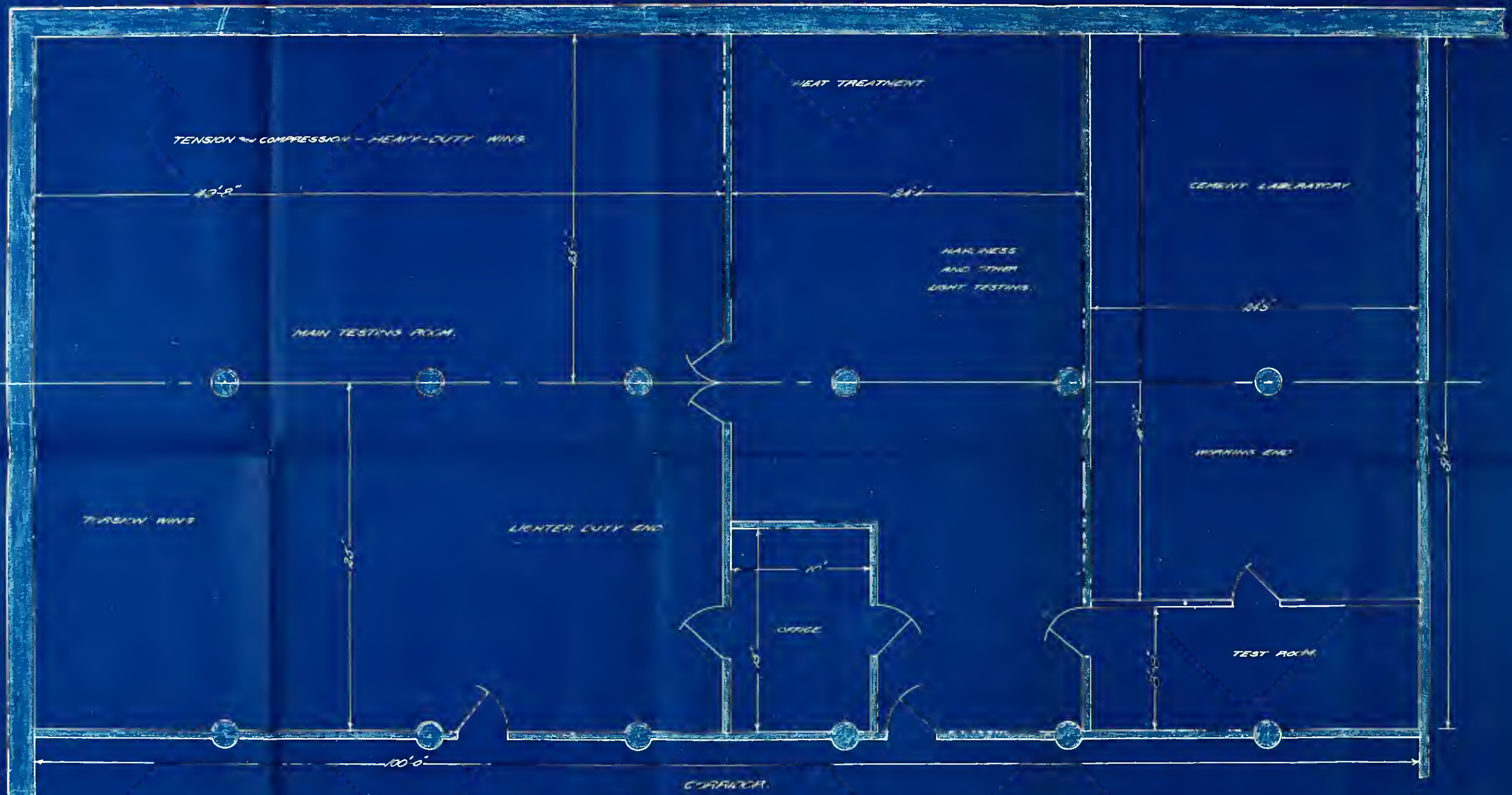


Cement Impact Testing Machine.

General.

All machines that require power drive are to have individual motors attached to them.

All machines described include whatever machines are of use now in the present laboratory, making it necessary to add only the 100,000 lbs. Olsen Testing machine, the 230,000 in. lbs. torsion machine. The Wire testing machine in the main testing room. The Lathe and drill press and almost the entire tempering apparatus and also the ball bearing machine for the central testing room. The cement laboratory includes the few machines in present use.



MATERIALS LABORATORY—FLOOR LAYOUT
RECOMMENDED TO
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SCALE: 1/8" = 1 FOOT

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DRAWING N
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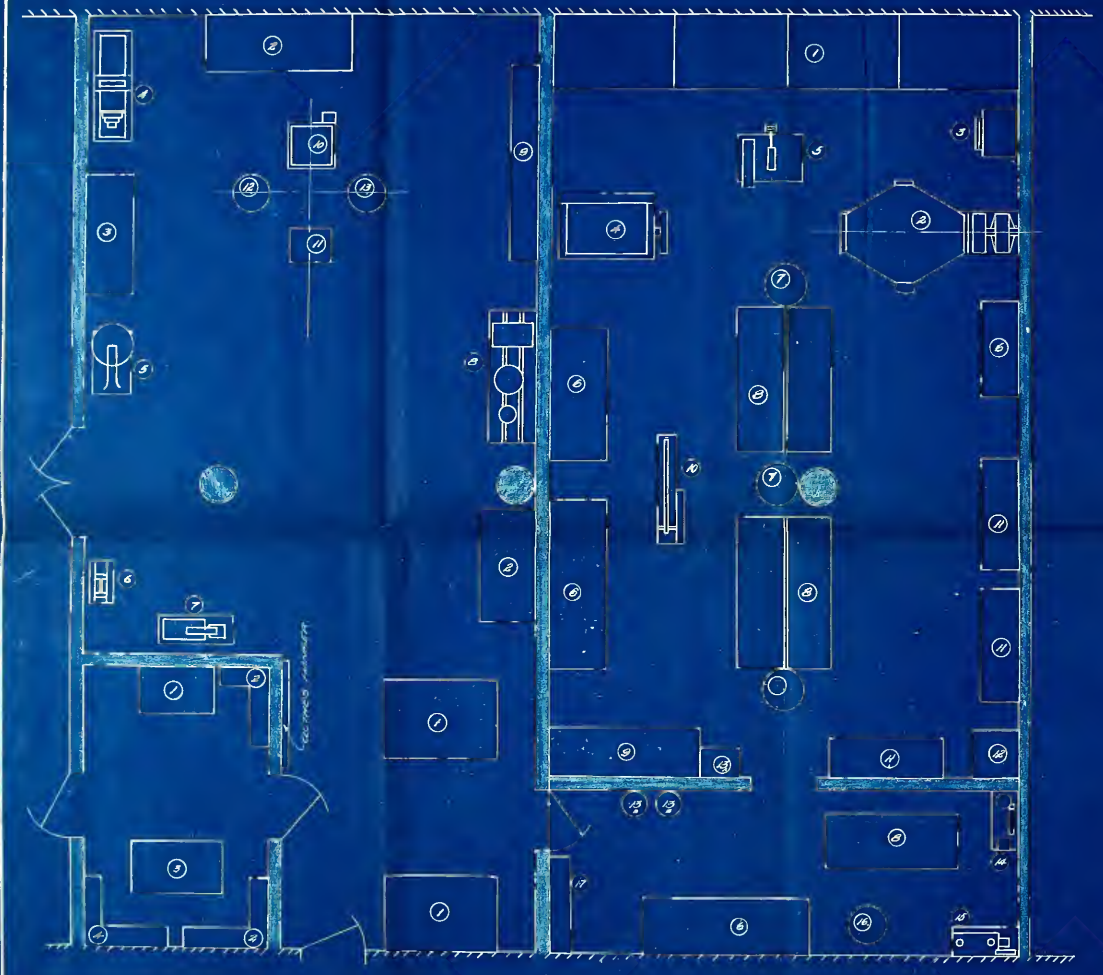

CEMENT LABORATORY.

MRK.	DESCRIPTION	NO.
1	STORAGE BINS	4.
2	CEMENT MIXER - MOTOR ATTACHED	1.
3.	CRUSHER	1.
4	RATTLER - DIRECT MOTOR DRIVE	1.
5.	BALL MILL " " "	1.
6	CUPBOARDS and STORAGE	4
7	WASTE CANS	3.
8	WORK TABLE	5
9	CLEANING TABLES	1
10	SCALES - FAIRBANKS-MORSE.	1.
11	WATER and MOIST AIR TANKS	3.
12	SETTLING TANK	1.
13	SINKS AND WASH BOWLS.	3.
14	SHOT CEMENT TESTER	1.
15	40,000 LBS. COMPRESSION TEST MACHINE.	1.
16	DORRY HARDNESS TESTING MACHINE.	1.
17	FILES	

ACCESSORIES:

INCLUDES MOULDS, SCALES, GRADUATES AND NUMEROUS OTHER NECESSITIES.

CENTRAL TESTING ROOM.

MRK.	DESCRIPTION.	NO.
1	STUDY TABLES	2
2	CUPBOARDS and STORAGE.	2
3	WORKING TABLE	2
4	LATHE - AVERAGE MEDIUM DUTY	1
5	DRILL PRESS " "	1
6	WHITE - SOUTHERN ENDURANCE TESTER	1
7	IMPACT TESTING MACHINE.	1
8	SMALL TESTING MACHINES:- HARDNESS ETC.	—
9	FURNACES AND PYROMETERS.	3-3
10	OIL TEMPERING OVEN	1
11	ELECTRIC " FURNACE.	1
12	CIRCULATING WATER TANK	1
13	" OIL TANK.	1
	OFFICE.	
1	DESK	1
2	FILES	2
3	TABLE	1
4	LIBRARY CASE.	1

MATERIALS LABORATORY RECOMMENDED TO
ARMOUR INSTITUTE OF TECHNOLOGY
SCALE:- 1/4" = 1FT.
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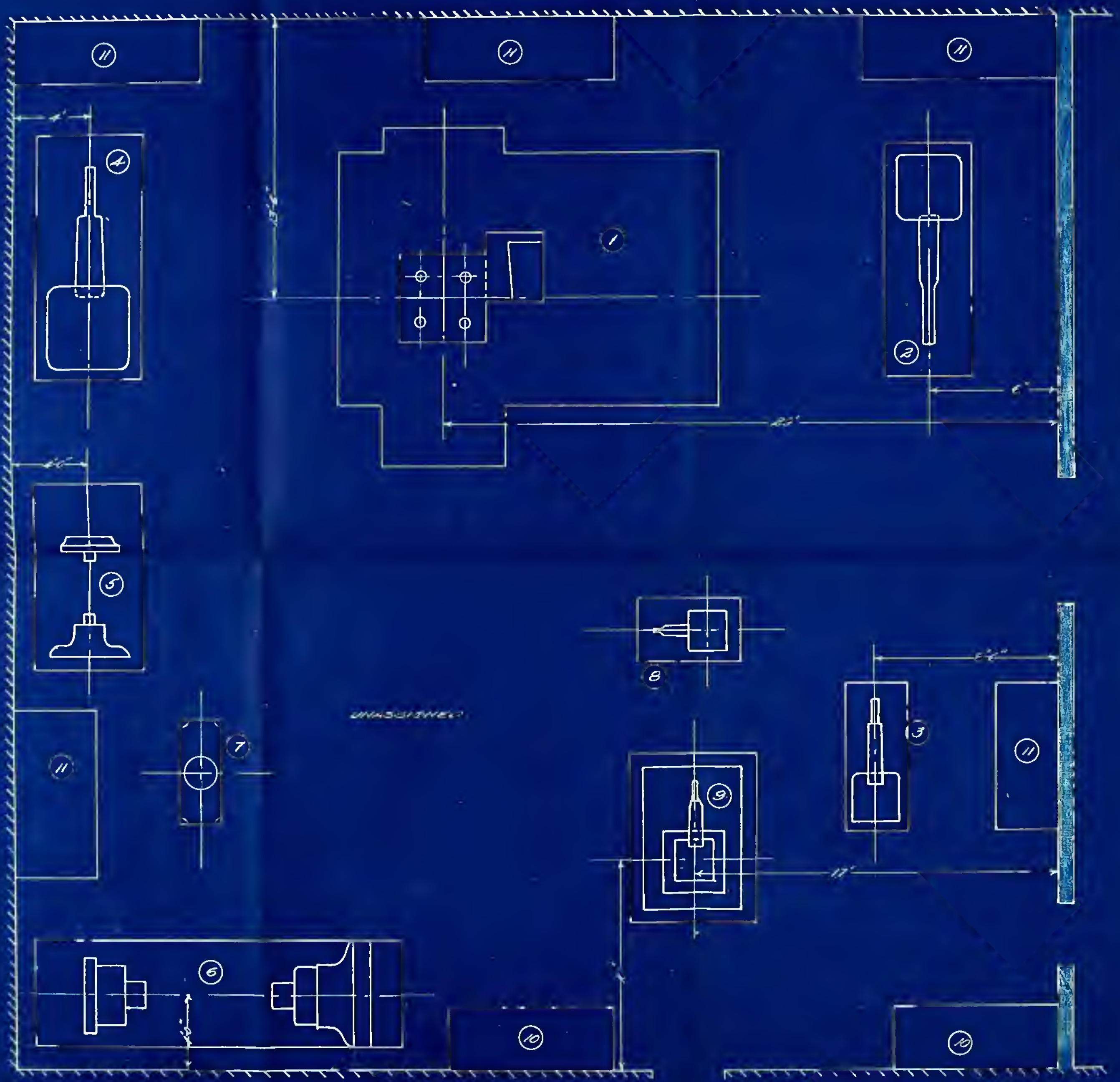
BY

DRAWING Nº
2A.



MARK	MAIN TESTING ROOM. DESCRIPTION.	No.
1	400,000 LBS. OLSEN TESTING MACHINE.	1
2	100,000 " " " "	1
3	60,000 " " " "	1
4	200,000 " RIEHLE " "	1
5	50,000 IN. " TORSION " "	1
6	230,000 " " " " "	1
7	WIRE TORSION TESTING MACHINE.	1
8	10,000 LBS. OLSEN WIRE TENSION MACHINE	1
9	50,000 " " BELT TESTING "	1
10	CUPBOARDS and STORAGE.	2
11	TABLES.	5
12	OVERHEAD CRANES	2

MATERIALS LABORATORY - RECOMMENDED TO
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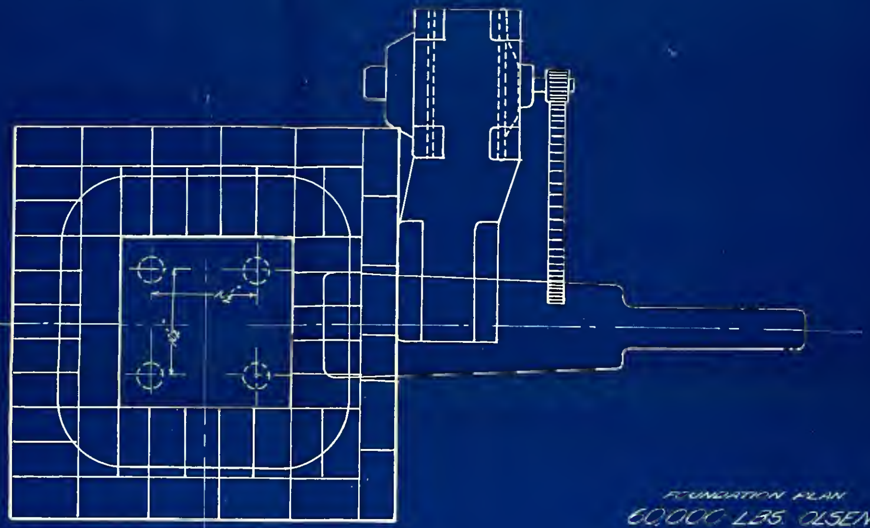
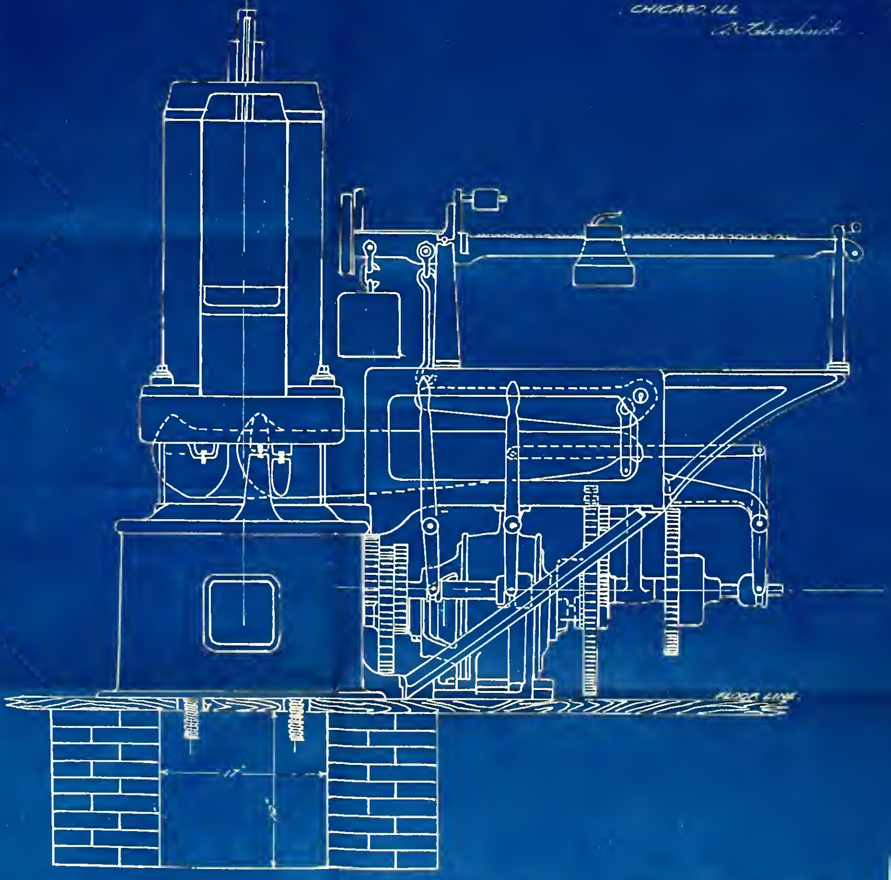
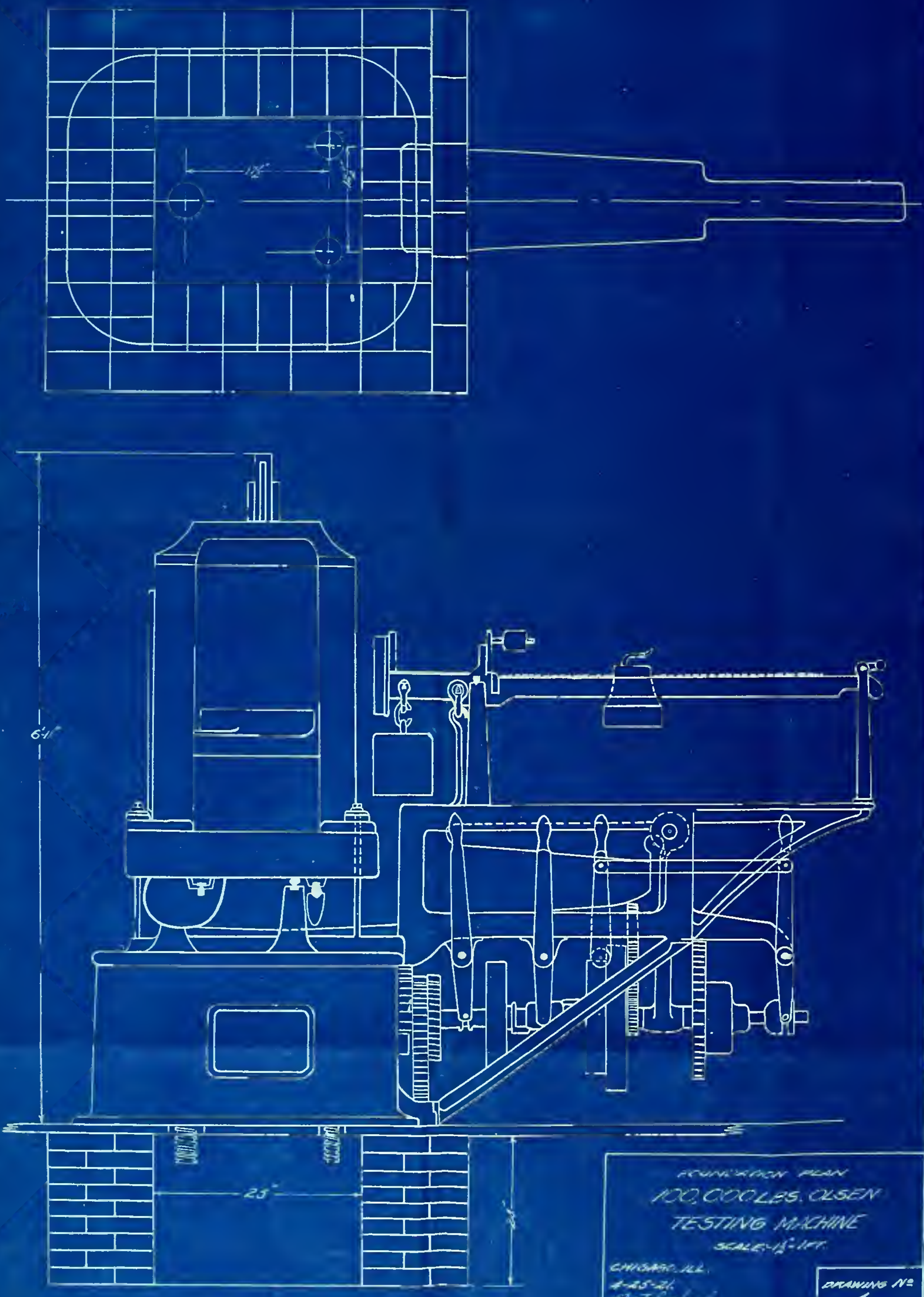




FOUNDATION PLAN
60,000 LBS. OLSEN
TESTING MACHINE.
SCALE:- 2" = 1 FT
CHICAGO, ILL 4-25-21.
A. Fabrochuck

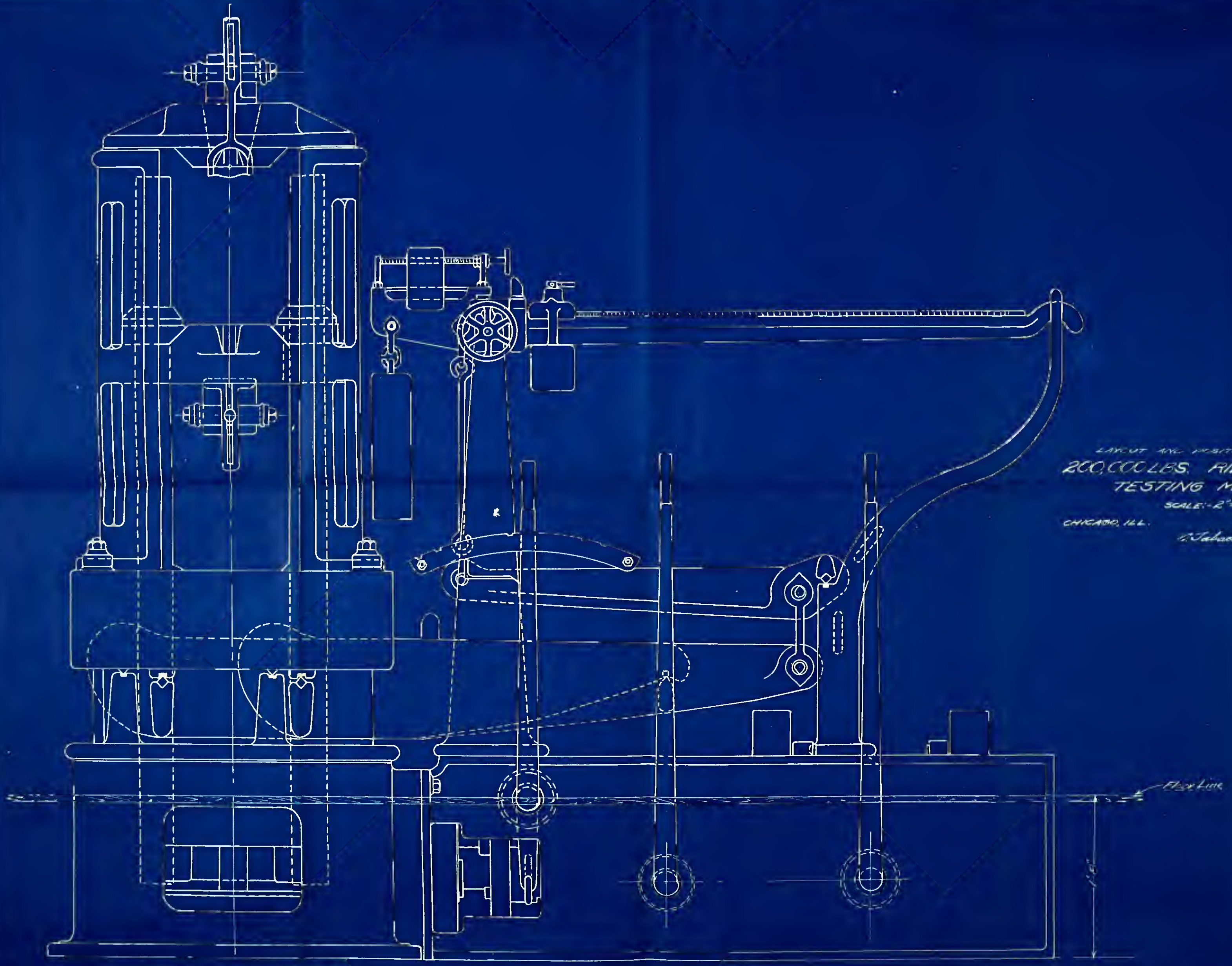
DRAWING No
3.



FOUNDATION PLAN
100,000 LBS. OLSEN
TESTING MACHINE
SCALE-1½"=1FT.

CHICAGO, ILL.
4-25-21.
A. Jakobsen

DRAWING No
4.



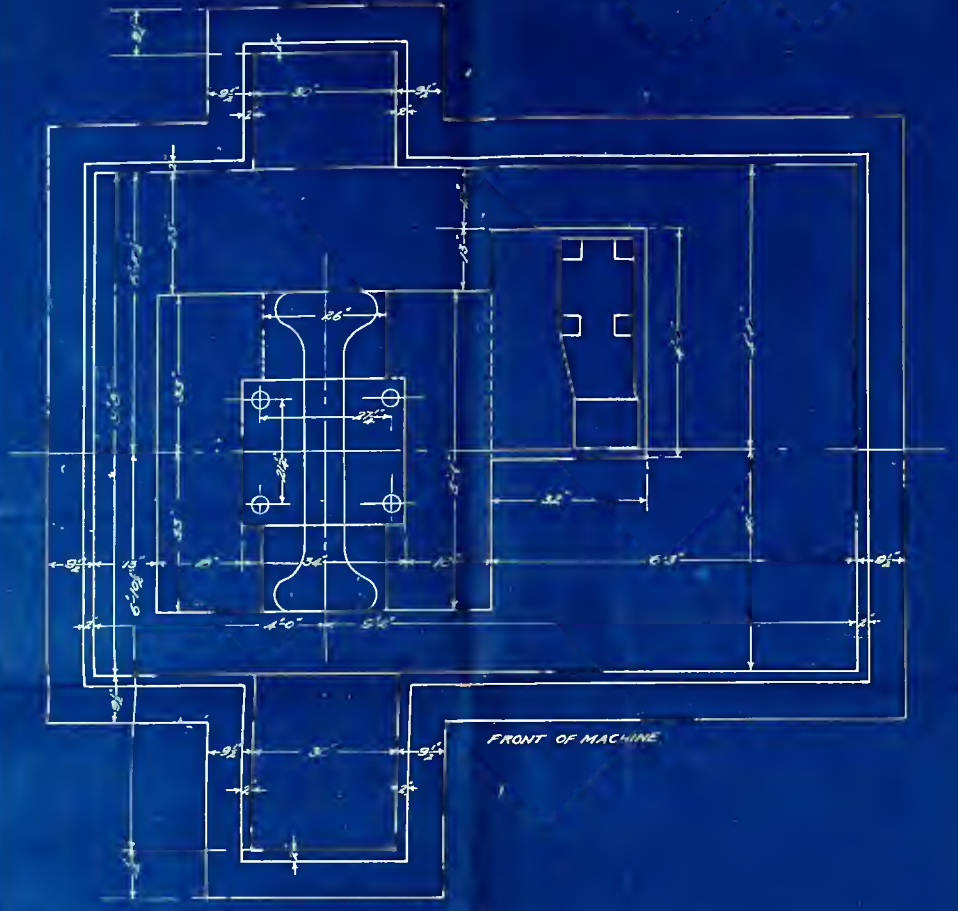
LAYOUT AND POSITIONING OF A

200,000 LBS. RIEHLE BROS.
TESTING MACHINE.

SCALE:- 2" = 1 FT.

CHICAGO, ILL. 4-25-21

DRAWING No.
5.



FOUNDATION PLAN

400,000 LBS. OLSEN

TESTING MACHINE

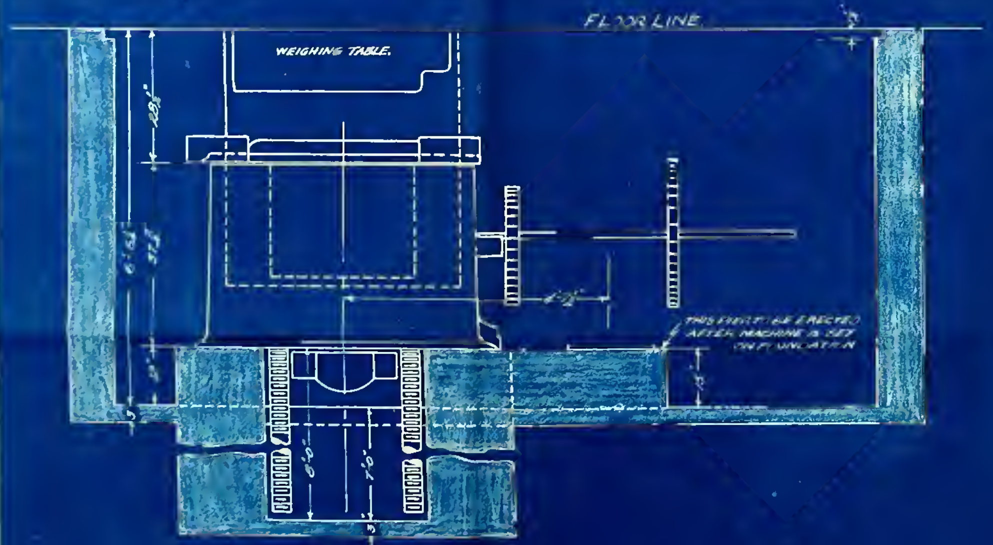
SCALE: ½" = 1 FT.

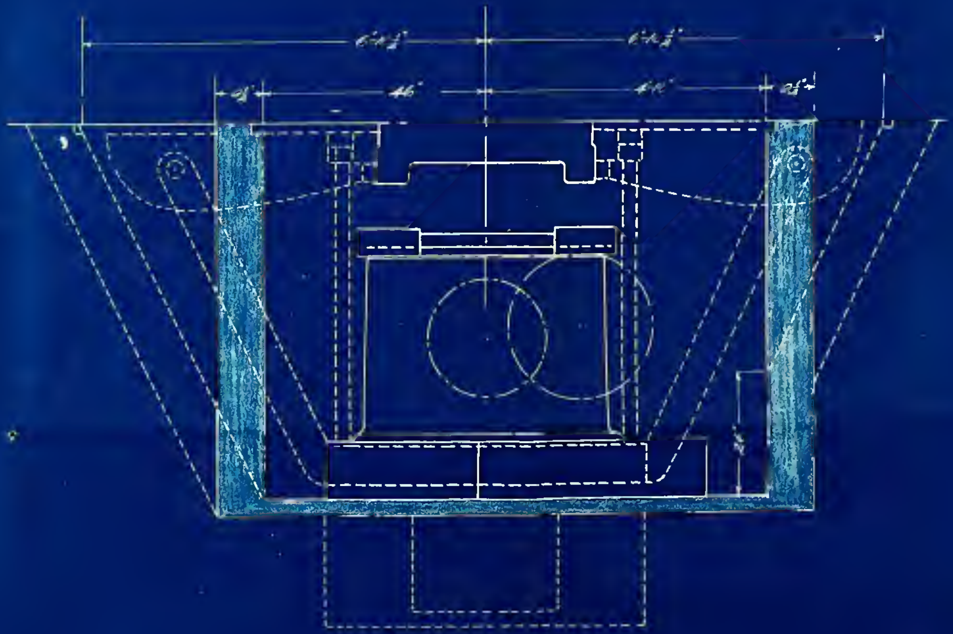
CHICAGO, ILL. 4-25-21

A. Jabachnik

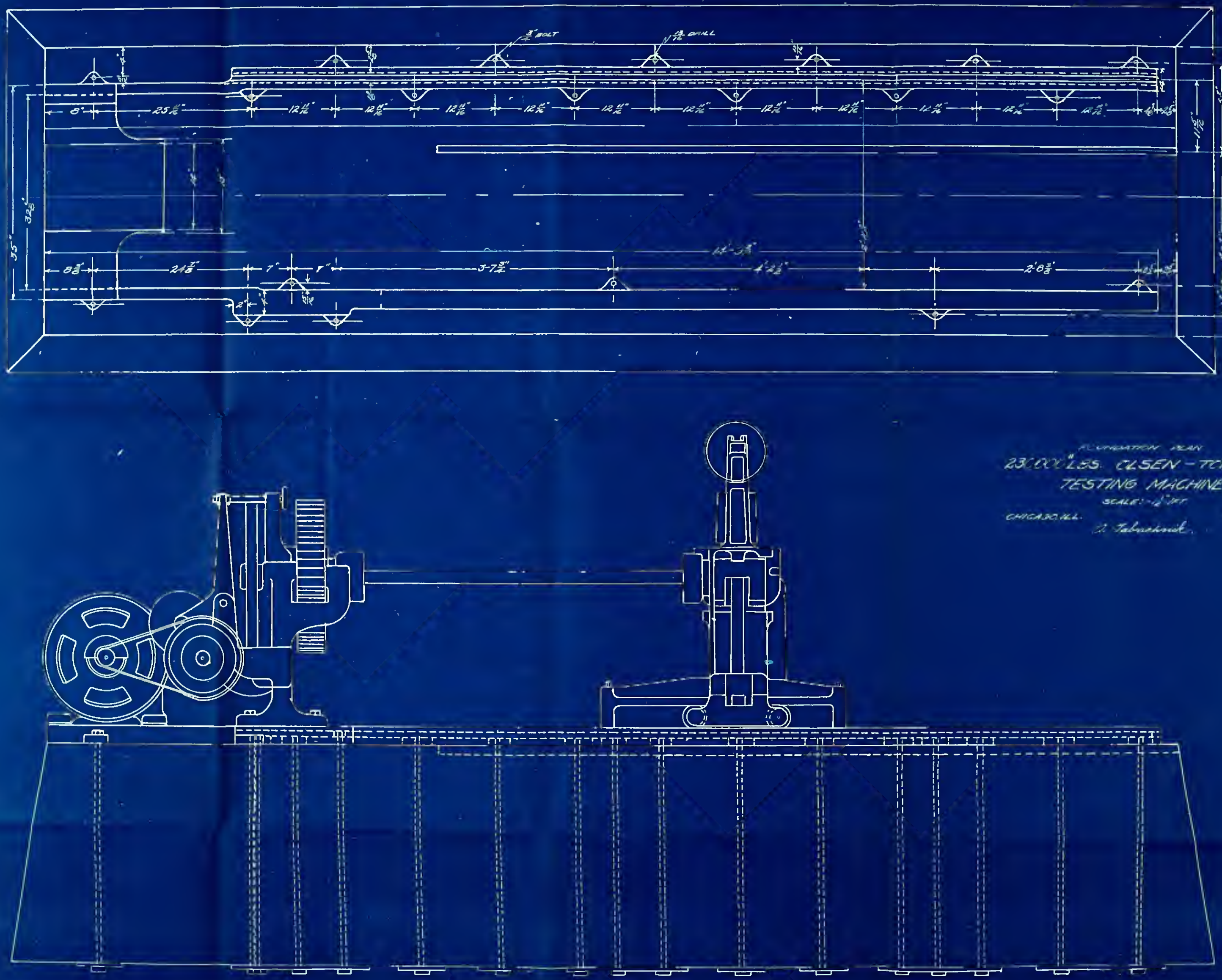
NOTE:–

11'-4" HEADROOM REQ. FOR MACHINE





DRAWING No.
6



FOUNDATION PLAN
230,000" LBS. OLSEN – TORSION
TESTING MACHINE
SCALE:- 1/2"=1FT.

CHICAGO, ILL. 5-25-21.
A. Tabachnick.

DRAWING Nº
7.